JC17 Rec'd PCT/PTO 10 MAY 2001

| SUBSTITUTE FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE<br>**TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371** | | ATTORNEY'S DOCKET NUMBER<br>12758-035001<br>U.S. APPLICATION NO. (If Known, see 37 CFR 1.5) 09/831617 |
|---|---|---|
| INTERNATIONAL APPLICATION NO.<br>PCT/DE99/03614 | INTERNATIONAL FILING DATE<br>12 November 1999 | PRIORITY DATE CLAIMED<br>13 November 1998 |
| TITLE OF INVENTION<br>**METHOD FOR TRANSMITTING DATA IN A RADIOCOMMUNICATION SYSTEM WITH CDMA SUBSCRIBER SEPARATION AND VARIABLE SPREAD FACTORS** | | |
| APPLICANT(S) FOR DO/EO/US<br>**Stefan Bahrenburg, Paul Baier, Dieter Emmer, Jurgen Mayer, Johannes Schlee and Tobias Weber** | | |

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).
4. ☐ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is attached hereto (required only if not communicated by the International Bureau).
   b. ☐ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.
8. ☐ An English language translation of amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11 to 16 below concern other documents or information included:**

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☐ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☐ Other items or information:
    ☐ English translation of International Search Report
    ☐
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| U.S. APPLICATION NO. (IF KNOWN) 09/831617 | INTERNATIONAL APPLICATION NO. PCT/DE99/03614 | ATTORNEY'S DOCKET NUMBER 12758-035001 | |
|---|---|---|---|
| 17. ☒ The following fees are submitted: | | CALCULATIONS | PTO USE ONLY |
| **Basic National Fee ( 37 CFR 1.492(a)(1)- (5) ):**<br>Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO ............ **$1000**<br>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO ........ **$860**<br>International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO..................... **$710**<br>International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4).................. **$690**<br>International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4)........................... **$100** | | | |
| **ENTER APPROPRIATE BASIC FEE AMOUNT =** | | $860.00 | |
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| Claims | Number Filed | Number Extra | Rate | | |
|---|---|---|---|---|---|
| Total Claims | 8 - 20 = | 0 | x **$18** | $0.00 | |
| Independent Claims | 2 - 3 = | 0 | x **$80** | $0.00 | |
| MULTIPLE DEPENDENT CLAIMS(S) (if applicable) | | | + **$270** | $0.00 | |
| **TOTAL OF ABOVE CALCULATIONS =** | | | | $860.00 | |
| ☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. | | | | $0.00 | |
| **SUBTOTAL =** | | | | $860.00 | |
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| **TOTAL FEES ENCLOSED =** | | | | $860.00 | |
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**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b) must be filed and granted to restore the application to pending status.**

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09/831617

Attorney's Docket No.: 12758-035001 / 1998P08170WOUS

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IN THE UNITED STATES RECEIVING OFFICE

Applicant : Stefan Bahrenburg *et al.*
Serial No. : 09/831,617
Filed : May 10, 2001
Title : METHOD FOR TRANSMITTING DATA IN A RADIOCOMMUNICATION SYSTEM WITH CDMA SUBSCRIBER SEPARATION AND VARIABLE SPREAD FACTORS

**BOX PCT**
Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Prior to examination, please amend the above-identified application, as follows:

IN THE TITLE:

Please change the title of the invention to - - DATA TRANMISSION SYSTEM THAT USES CDMA SUBSCRIBER SEPARATION AND VARIABLE SPREAD FACTORS- -.

IN THE CLAIMS:

Please amend claims 1 to 8, as follows:

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September 19 2001
Date of Deposit

Samantha Bell
Signature

Samantha Bell
Typed or Printed Name of Person Signing Certificate

1. (Amended) A method [for] of transmitting data [transmission] in a radio communications system [with CDMA subscriber separation and variable spread factors, in which], the method comprising:

[-] transmitting signals from at least two data streams [and with] having data symbols spread by [means of] spread codes [(c) are transmitted], the signals being transmitted at the same time in one channel, wherein [in which case] different spread factors are [(SF) which are less than or equal to a maximum spread factor (SEInax) can be] used for the signals[,];

[- at the receiving end, the signals are detected with the aid of the spread codes (c), characterized - in that, at the receiving end, a number of] forming a virtual spread code [codes (cv) which are each related only to individual symbols or symbol groups in the symbol are formed] for a symbol in one of the signals having a spread factor [(SF)] which is less than a [the] maximum spread factor [(SFmax),] code;

[- the detection of this signal is carried out] detecting the one of the signals using the virtual spread [codes (cv),]; and

[-] arranging [the] detection results[, with the virtual spread codes (cv), are arranged in a row] to form a [the receiving-end] data stream [of] that corresponds to the one of the signals [signal with the lower spread factor] .

2. (Amended) The method of [as claimed in] claim 1, further comprising changing the virtual [in which a] spread code for a new symbol in one of the signals [(c) with a spread factor (SF) which is less than the maximum spread factor (Sfmax) is changed from symbol to symbol or from symbol group to symbol group].

3. (Amended) The method of [as claimed in] claim 2, wherein changing [in which the change in] the virtual spread code comprises [(c) corresponds to the] splitting the [into] virtual spread code [codes (cv)].

4. (Amended) The method of [as claimed in] claim 2, wherein a [or 3, in which the] length of the virtual spread code [codes (cv)] corresponds to a [the symbol] length of a symbol having the maximum spread factor.

5. (Amended) The method [as claimed in one of the preceding claims, in which] of claim 1, wherein detecting is performed using a detection device [(DE) is] designed for a number of channels that [which] corresponds to a [the] number of channels associated with the maximum spread factor [(SFmax), with detection being carried out on the basis of virtual spread codes for processing of signals with different spread factors].

6. (Amended) The method of [as claimed in] claim 5, wherein [in which] the detection device performs detecting by eliminating [(DE) carries out joint detection with elimination of] at least one interference signal in the signals.

7. (Amended) The method [as claimed in one of the preceding claims, in which] of claim 1, wherein:

[-] the data symbols are at least partially superimposed to form a received signal[,];

[-] the received signal is sampled and [is] passed to a reception matrix [(e),];

[-] a system matrix contains [(A) is occupied with] values[, which] that are related to a signal-specific channel impulse responses, wherein [on the basis of a band structure, with] (i) adjacent positions in the system matrix contain [(A) being occupied in such a manner that the] values of [the] different signals [alternate and the occupied], (ii) positions in the system matrix are aligned to correspond [corresponding] to [the] superimpositions of [between] the data symbols, [with] and (iii) correspondingly more adjacent positions in the system matrix are [being] provided for [the] signals with [the] lower spread [factor,] factors; and

[- linear] detection is performed [carried out] for [the] data symbols in the at least two data streams, using the received signal, by linking the system matrix [(e)] and the reception matrix [(e)].

8. (Amended) A receiving device for a radio communications system, comprising:

[which has] at least one [associated] antenna [(AT)] for receiving [a received signal,] signals; and

[having] a channel estimator [(KS)] for determining signal-specific channel impulse responses of at least two received signals in simultaneously transmitted data streams having [with] data symbols spread by [means of] spread codes [(c),];

wherein [in which case] different spread codes are used [(SF), which are less than the maximum spread factor (SFmax), can be set] for the at least two received signals,

Please add claim 9, as follows:

- -9. The method of claim 3, wherein a length of the virtual spread code corresponds to a length of a symbol having the maximum spread factor. - -

## REMARKS

Claims 1 to 9 are pending in the application, with claims 1 to 8 having been amended, as shown above, to attend to minor informalities. Claims 1 and 8 are the independent claims. Favorable consideration and early passage to issue are respectfully requested. The claims, without brackets and underlines, are shown in the attached Appendix.

Applicants' undersigned attorney can be reached at the address shown below.

No fee is believed to be due for this Preliminary Amendment. However, if a fee is due, please charge the fee to Deposit Account No. 06-1050.

Respectfully submitted,

Date: September 19, 2001

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APPENDIX

1. A method of transmitting data in a radio communications system, the method comprising:

transmitting signals from at least two data streams having data symbols spread by spread codes, the signals being transmitted at the same time in one channel, wherein different spread factors are used for the signals;

forming a virtual spread code for a symbol in one of the signals having a spread factor which is less than a maximum spread factor;

detecting the one of the signals using the virtual spread code; and

arranging detection results to form a data stream that corresponds to the one of the signals.

2. The method of claim 1, further comprising changing the virtual spread code for a new symbol in one of the signals.

3. The method of claim 2, wherein changing the virtual spread code comprises splitting the virtual spread code.

4. The method of claim 2, wherein a length of the virtual spread code corresponds to a length of a symbol having the maximum spread factor.

5. The method of claim 1, wherein detecting is performed using a detection device designed for a number of channels that corresponds to a number of channels associated with the maximum spread factor.

6. The method of claim 5, wherein the detection device performs detecting by eliminating at least one interference signal in the signals.

7. The method of claim 1, wherein:

the data symbols are at least partially superimposed to form a received signal;

the received signal is sampled and passed to a reception matrix;

a system matrix contains values that are related to a signal-specific channel impulse responses, wherein (i) adjacent positions in the system matrix contain values of different signals, (ii) positions in the system matrix are aligned to correspond to superimpositions of the data symbols, and (iii) correspondingly more adjacent positions in the system matrix are provided for signals with lower spread factors; and

detection is performed for data symbols in the at least two data streams, using the received signal, by linking the system matrix and the reception matrix.

8. A receiving device for a radio communications system, comprising:

at least one antenna for receiving signals; and

a channel estimator for determining signal-specific channel impulse responses of at least two received signals in simultaneously transmitted data streams having data symbols spread by spread codes;

wherein different spread codes are used for the at least two received signals,

9. The method of claim 3, wherein a length of the virtual spread code corresponds to a length of a symbol having the maximum spread factor.

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Description

Method for data transmission in a radio communications system with CDMA subscriber separation and variable spread factors

The invention relates to a method for data transmission and to a radio communications system with CDMA subscriber separation and variable spread factors.

In radio communications systems, data (for example voice, picture information or other data) are transmitted via a radio interface by means of electromagnetic waves. The radio interface relates to a connection between a base station and subscriber stations, in which case the subscriber stations may be mobile stations or fixed-position radio stations. The electromagnetic waves are in this case emitted at carrier frequencies which are in the frequency band provided for the respective system. Frequencies in the frequency band around about 2000 MHz are provided for future radio communications systems, for example the UMTS (Universal Mobile Telecommunication System), or other 3$^{rd}$ generation systems.

From the SMG L1 Expert Group, Tdoc 120/98, Bocholt, from May 18 to 20 1998, pages 16-19, it is known that a radio interface will be provided for future radio communications systems, which envisages simultaneous transmission of a number of signals, whose data symbols are spread by means of spread codes, in one frequency band. This method is referred to as CDMA (code division multiple access) since it allows the receiver to use the spread codes to separate the signals once again and to detect the data symbols in the various data streams.

The CDMA transmission method allows interference-resistant transmission at a connection data rate which can easily be adapted

by assignment of one or more spread factors, or by varying the spread factor.

However, the use of different spread factors results in the problem at the receiving end of resolving different symbol and data rates and of reacting flexibly to changes in the spread factor. No adequate solution options are yet known for this at the moment. The method having the features of claim 1 and the receiving device having the features of claim 8 are solution options for this problem. Advantageous developments of the invention are specified in the dependent claims.

According to the invention, reference is made to a maximum spread factor, which can be predetermined, if there are a number of signals with different spread factors. At the receiving end, a number of virtual spread codes are formed for a signal with a spread factor which is less than the maximum spread factor, each individual one of which virtual spread codes detects only specific symbols or symbol groups from a number of associated symbols from the received data stream. If the maximum spread factor is divided by the smaller spread factor corresponding to the virtual spread code, this results in the number of virtual spread codes which should be used for detection of the signal with a low spread factor. These virtual spread codes are the basis for further evaluation of this signal, since the detection of this signal is carried out using the virtual spread codes. The detection results of the detection process with the virtual spread codes are then arranged in a row to form the receiving-end data stream of the corresponding signal.

The symbols in a data stream are thus not all evaluated in one detecting channel, and the data stream is split on a symbol or symbol group basis between a number of virtual channels whose data rate is, as far as possible, the same. This nevertheless allows joint detection with the same data rate in the channels to be modelled for channels with different spread factors and

thus different data rates.

This also allows all the signals contained in the received signal to be evaluated using a standard symbol rate, irrespective of the spread factors actually used. The receiving device is designed for the maximum number of signals and the maximum spread factor but, with very minor adaptations, has no problems in processing a smaller number of signals, at least some of which, however, use a lower spread factor.

In principle, this solution is suitable for all types of CDMA detectors, i.e. for Rake receivers and for detectors using joint detection. A solution such as this can be implemented particularly easily.

According to advantageous developments of the invention, a modification of the virtual spread codes can also support code hopping or code scrambling (based on W-CDMA transmission in accordance with SMG L1 Expert Group, Tdoc 120/98, Bocholt, May 18-20, 1998). In this case, the virtual spread codes are chosen such that a different spread code, with a low spread factor, can be assumed for each symbol or for one symbol group.

Particularly with short spread codes (low spread factor), diversity effects are utilized by means of scrambling. Scrambling results in the chips in the spread codes being changed. This may be done by means of modulo 2 operations, by general multiplication by a sequence, and with complex or real values. Once a scrambling period has elapsed, the chips in the spread codes are changed in the same way. If the scrambling period is equal to the spread code length, then spread codes are effectively unchanged. If the period is longer than the symbol length, the spread code changes from symbol to symbol, so that the cycle may extend over a number of symbols, over one timeslot (W-CDMA proposal) or over a frame or more.

If the scrambling period is exactly the same length as the maximum spread factor, then this results in a particular advantage. The detector can thus not only carry out the detection process taking account of identical spread codes for the maximum spread factor with little effort, but can also take account of scrambling of spread codes with a low spread factor, with the same effort.

If, for example, as with W-CDMA, the only spread factors, code lengths or code symbol lengths which are allowed are those which are obtained by dividing the maximum spread factor by integer numbers, virtual spread codes can always be used in the manner described above, with and without consideration of scrambling.

In order to allow a detection device to be developed irrespective of the current assignment of spread codes to connections, the invention proposes that a detection device be designed for a number of channels which corresponds to the number of channels with the maximum spread factor, and with detection being carried out on the basis of virtual spread codes for processing signals with different spread factors. This is particularly important when the detection device carries out joint detection (in accordance with DE 41 21 356 A1) with elimination of at least one interference signal.

A further improvement in the method according to the invention, which can also be used without virtual spread codes, is obtained if it is remembered that the data symbols are at least partially superimposed to form a received signal. This applies not only to intersymbol interference (ISI) but also to interference between the subscriber signals (MAI). The received signal is sampled and is passed to a reception matrix. Furthermore, a system matrix is occupied with system-specific values, related to channel impulse responses, based on a band structure.

Adjacent positions in the system matrix are occupied in such a manner that the signal-specific values of the different signals alternate, and the occupied positions are aligned on the basis of the superimpositions between the symbols. The values of a subscriber signal with a low or identical spread factor are arranged between two values of a subscriber signal with a large spread factor as a function of the spread factor ratio. Correspondingly more adjacent positions are provided for subscriber signals with a lower spread factor. Linear detection is then carried out for the data symbols in the at least two data streams by linking the system matrix and the reception matrix.

This results in a band structure which is better than that in the literature, see A.Klein, "Multi-user detection of CDMA signals - algorithms and their application to cellular mobile radio", VDI Verlag, 1996, pages 38-43, and which complies with the requirements for variable spread codes. The use of different spread factors leads to more interference between symbols in different subscriber signals. The setting up of the system matrix according to the invention contributes to a detection process requiring little effort, despite this interference. When such optimized detection is carried out, this results in shorter computation times which allow the detector to switch to an idle mode. This reduces the power consumption and/or the heat emitted from the unit.

Exemplary embodiments of the invention will be explained in more detail with reference to the attached drawings, in which:

Figure 1 shows a schematic illustration of a radio communications system,

Figure 2 shows a transmitting device,

Figure 3 shows a receiving device, and

Figures 4, 5 show a breakdown of spread codes into virtual spread codes.

The mobile radio system illustrated in Figure 1 as an example of a radio communications system comprises a large number of mobile switching centers MSC which are networked with one another and produce access to a landline network PSTN. Furthermore, these mobile switching centers MSC are each connected to at least one device RNM for assignment of radio resources. Each of these devices RNM in turn allows a connection for at least one base station BS.

Such a base station BS can use a radio interface to set up a connection to subscriber stations, for example mobile stations MS or other types of mobile and stationary terminals. At least one radio cell is formed by each base station BS. Figure 1 shows connections for transmitting user information between a base station BS and mobile stations MS.

An operation and maintenance center OMC provide monitoring and maintenance functions for the mobile radio system, or for parts of it. The functionality of this structure can be transmitted to other radio communication systems in which the invention may be used, in particular for subscriber access networks with wire-free subscriber access.

A transmitter structure as shown in Figure 2 is used for a CDMA transmission method. K data streams are intended to be transmitted via the radio interface. Channel coding, scrambling (interleaving), modulation and spreading of the data are carried out. The spreading is carried out using individual spread codes c1…c5, which make it possible to distinguish between subscriber signals within the signal mixture. The individual subscriber signals are then added, and the sum signal is used to form a radio block. Radio block formation relates primarily to a transmission system using burst transmission. For

continuous transmission, as in W-CDMA operation, the data in a timeslot are combined within the radio block formation. The signal is then filtered in a chip impulse filter and is converted in a D/A converter to an analogue signal, which can be amplified and transmitted via antennas AT.

The corresponding structure of a receiving device is shown in Figure 3. Once the signals have been received via the antenna AT at the receiving radio station, and have then been amplified and converted to baseband, the received signal is sampled and A/D converted, so that the received signal can be supplied to a digital low-pass filter. The digitized signal is now supplied in parallel to a channel estimator KS and a detection device DE. In this case, it is assumed for the subsequent analysis that the received signal is in the form of a reception matrix e, where

$$e = A*d + n.$$

A describes a system matrix, d indicates the data to be detected, in matrix form, and n is a matrix containing the noise element.

In the channel estimator KS, training sequences which are present in distorted form in the received signal, are compared with undistorted training sequences in the receiver, and the comparison is used to determine channel impulse responses which describe the transmission channel on a subscriber-specific basis. The system matrix A is produced using the channel impulse responses. The system matrix A contains values which are related to the individual channel impulse responses and are also referred to as the combined channel impulse response. The combined channel impulse response is obtained by convolution of the spread code c with the associated channel impulse response, individually for each subscriber signal.

Mathematically, a system matrix A is also used in a Rake receiver. In this case, the channel impulse responses take account of only specific paths, corresponding to the fingers of the Rake receiver. This can also be generalized to multi-user detection based on the Rake receiver.

The information required about the mobile radio channel may be obtained not only from pilot symbols, midambles or preambles etc., but also from the transmitted symbols themselves, as in the uplink path in IS-95.

If two signals with spread factors of SF=3 and SF=6 are assumed, with the channel impulse response having a length of four elements for both, then this results in a vector $b^1$ of length 9 = 6 + 4 -1, for the first signal (SF=6) and a vector $b^2$ of length 6 = 3 + 4 + -1 for the second signal (SF=3).

The vector b in each case describes the result of the individual convolution of the spread code c with the channel impulse response. This vector indicates the response of the transmission channel to a transmitted "1". The system matrix A is now filled as follows using these vectors $b^1$ and $b^2$.

$$A = \begin{pmatrix} b_1^1 & b_1^2 & 0 & 0 & 0 & 0 & .. & 0 \\ b_2^1 & b_2^2 & 0 & 0 & 0 & 0 & .. & 0 \\ b_3^1 & b_3^2 & 0 & 0 & 0 & 0 & .. & 0 \\ b_4^1 & b_4^2 & b_1^2 & 0 & 0 & 0 & .. & 0 \\ b_5^1 & b_5^2 & b_2^2 & 0 & 0 & 0 & .. & 0 \\ b_6^1 & b_6^2 & b_3^2 & 0 & 0 & 0 & .. & 0 \\ b_7^1 & 0 & b_4^2 & b_1^1 & b_1^2 & 0 & .. & 0 \\ b_8^1 & 0 & b_5^2 & b_2^1 & b_2^2 & 0 & .. & 0 \\ b_9^1 & 0 & b_6^2 & b_3^1 & b_3^2 & 0 & .. & 0 \\ 0 & 0 & 0 & b_4^1 & b_4^2 & b_1^2 & .. & 0 \\ .. & .. & .. & .. & .. & .. & .. & .. \\ 0 & 0 & 0 & 0 & 0 & 0 & .. & \end{pmatrix}$$

The alternate arrangement of vectors $b^1$ and $b^2$, with the vector $b^2$ being used more frequently owing to the low spread factor, results in the system matrix A having a band structure even when spread factors SF are used differently.

The combined channel impulse responses of the symbols between which interference is possible - these are both successive symbols in a signal and symbols for different subscriber signals, but transmitted at the same time - are located in adjacent positions in the system matrix A. It should be noted that, in the above example, the first and second, the fourth and fifth, etc., columns can also be interchanged. In general, when setting up the system matrix A, care must be taken to ensure that the combined channel impulse responses of the interfering symbols are close to one another and that the number of positions to be reserved in the system matrix A for the signals is inversely proportional to their spread factors.

Corresponding to the exemplary embodiment, joint detection is carried out in the detection device DE, in which case, however, every other linear receiver can also be used, for example, with decision feedback or other multi-subscriber detectors. The band structure of the system matrix A in this case considerably simplifies matrix inversion for these detectors, for example carrying this function out by, for example, Cholesky decomposition.

In this case, it is necessary to solve the equation

$$\hat{d} = \left(A^{*T}A\right)^{-1} A^{*T} e$$

where $\hat{d}$ are the estimated data symbols. The detected data are then demodulated, descrambled (deinterleaved) and channel-decoded, so that separate data streams 1 to K are once again obtained.

Further details can be found in J.Mayer, J.Schlee, T.Weber, "Realtime feasibility of Joint Detection CDMA", Proceedings of the 2nd European Personal Mobile Communications Conference, Bonn, pages 245-252, Sept. 1997.

Data detection will now be described in conjunction with Figures 4 and 5. In this case, it is assumed that the maximum spread factor is SFmax=16, and that the detection device is designed for a maximum of eight subscriber signals to be processed in parallel. This results in a maximum load of:

$$Lmax = 8 * 1/SFmax.$$

The actual load is given by:

$$L = \sum_{k=1}^{K} \frac{1}{SF_k}$$

For the following example, five connections with the spread codes c1 to c5 are supplied at the same time via the radio interface. Four connections use the basic data rate and have a spread factor of SF=16, while the fifth connection is operated at four times the data rate, and with a spread factor of SF=4. This results in the maximum load.

Each spread code c1 to c4 comprises 16 chips, with the 16 chips being freely chosen on the basis of Figure 4 for the four connections with the spread codes c1…c4, thus resulting in spread codes which are as orthogonal as possible to one another. The fifth spread code c5, whose basic symbol comprises only four chips, is thus repeated four times within the 16 chips. Four times the amount of data is thus also transmitted, however, that is to say four symbols in the time interval illustrated in Figure 4.

In a corresponding manner to the exemplary embodiment, each of the four successive spread codes c5 in the illustrated time interval are assigned to a

virtual spread code cv, and the value "0" is inserted for the other digits. Superimposition of the

virtual spread codes cv once again results in the sequence of the original spread codes c5. After the four symbols illustrated in Figure 4, the split into virtual spread codes cv is repeated so that, for example, the virtual spread code c51 which forms the first virtual channel thus detects the first, fifth and ninth symbol, etc.

It should be noted that a symbol group comprising a number of symbols, for example two symbols - corresponding to 8 chips - can also be assigned to a virtual spread code. This is particularly advantageous when no connection is being operated at the maximum spread factor SFmax.

Overall, the detection device DE now processes eight channels at the basic data rate, although different spread factors SF are used. Changes in the spread factor SF can be understood very easily in the receiver. This makes it possible for the receiving device to be in the form of an application-specific circuit (ASIC).

Depending on what the constellation of the spread codes c may be as well, the detection device DE can be designed in a fixed manner for the, for example, eight channels, which are also virtual channels. The eight spread codes c, which are also virtual spread codes and are associated with the channels, are still freely selectable. The detection results from the detection with the virtual spread codes associated with the spread code c5 are then arranged in a row in order to form the receiving-end data stream of the relevant subscriber signal.

A further improvement is obtained as shown in Figure 5. In this case, rather than selecting the same chip sequence four times, four different spread codes c51, c52, c53, c54 are selected for the fifth spread code c5. These may change cyclically, for example being interchanged in the form of a ring or being changed on the basis of a jump sequence, so that an additional

code diversity improvement is obtained by scrambling. This jump sequence

is agreed for setting up a connection, and can be modified during the connection.

Patent Claims

1. A method for data transmission in a radio communications system with CDMA subscriber separation and variable spread factors, in which

- signals from at least two data streams and with data symbols spread by means of spread codes (c) are transmitted at the same time in one channel in which case different spread factors (SF) which are less than or equal to a maximum spread factor (SFmax) can be used for the signals,
- at the receiving end, the signals are detected with the aid of the spread codes (c),

characterized

- in that, at the receiving end, a number of virtual spread codes (cv) which are each related only to individual symbols or symbol groups in the symbol are formed for a symbol having a spread factor (SF) which is less than the maximum spread factor (SFmax),
- the detection of this signal is carried out using the virtual spread codes (cv), and
- the detection results, with the virtual spread codes (cv), are arranged in a row to form the receiving-end data stream of the signal with the lower spread factor.

2. The method as claimed in claim 1, in which a spread code (c) with a spread factor (SF) which is less than the maximum spread factor (SFmax) is changed from symbol to symbol or from symbol group to symbol group.

3. The method as claimed in claim 2, in which the change in the spread code (c) corresponds to the splitting into virtual spread codes (cv).

4. The method as claimed in claim 2 or 3, in which the length of the virtual spread codes (cv) corresponds to the symbol length of the maximum spread factor.

5. The method as claimed in one of the preceding claims, in which

a detection device (DE) is designed for a number of channels which corresponds to the number of channels with the maximum spread factor (SFmax), with detection being carried out on the basis of virtual spread codes for processing of signals with different spread factors.

6. The method as claimed in claim 5, in which the detection device (DE) carries out joint detection with elimination of at least one interference signal.

7. The method as claimed in one of the preceding claims, in which

- the data symbols are at least partially superimposed to form a received signal,
- the received signal is sampled and is passed to a reception matrix (e),
- a system matrix (A) is occupied with values, which are related to signal-specific channel impulse responses, on the basis of a band structure, with adjacent positions in the system matrix (A) being occupied in such a manner that the values of the different signals alternate and the occupied positions are aligned corresponding to the superimpositions between the symbols, with correspondingly more adjacent positions being provided for the signals with the lower spread factor,
- linear detection is carried out for the data symbols in the at least two data streams by linking the system matrix (e) and the reception matrix (e).

8. A receiving device for a radio communications system, which has at least one associated antenna (AT) for receiving a received signal,
having a channel estimator (KS) for determining signal-specific channel impulse responses of at least two signals in simultaneously transmitted data streams with data symbols spread by means of spread codes (c), in which case different spread codes (SF), which are

less than the maximum spread factor (SFmax), can be set for the signals,

having a detection device (DE) for detection of the signals with the aid of the spread codes, with

- a number of virtual spread codes (cv) which are each related only to individual symbols or symbol groups in the signal being formed for a signal with a spread factor (SF) which is less than the maximum spread factor (SFmax),
- the detection of this signal can be carried out using the virtual spread code (cv), and
- the detection results with the virtual spread codes (cv) being arranged in a row in order to form the receiving-end data stream of the signal with the lower spread factor.

GR 98 P 8170

Abstract

Method for data transmission in a radio communications system with CDMA subscriber separation and variable spread factors

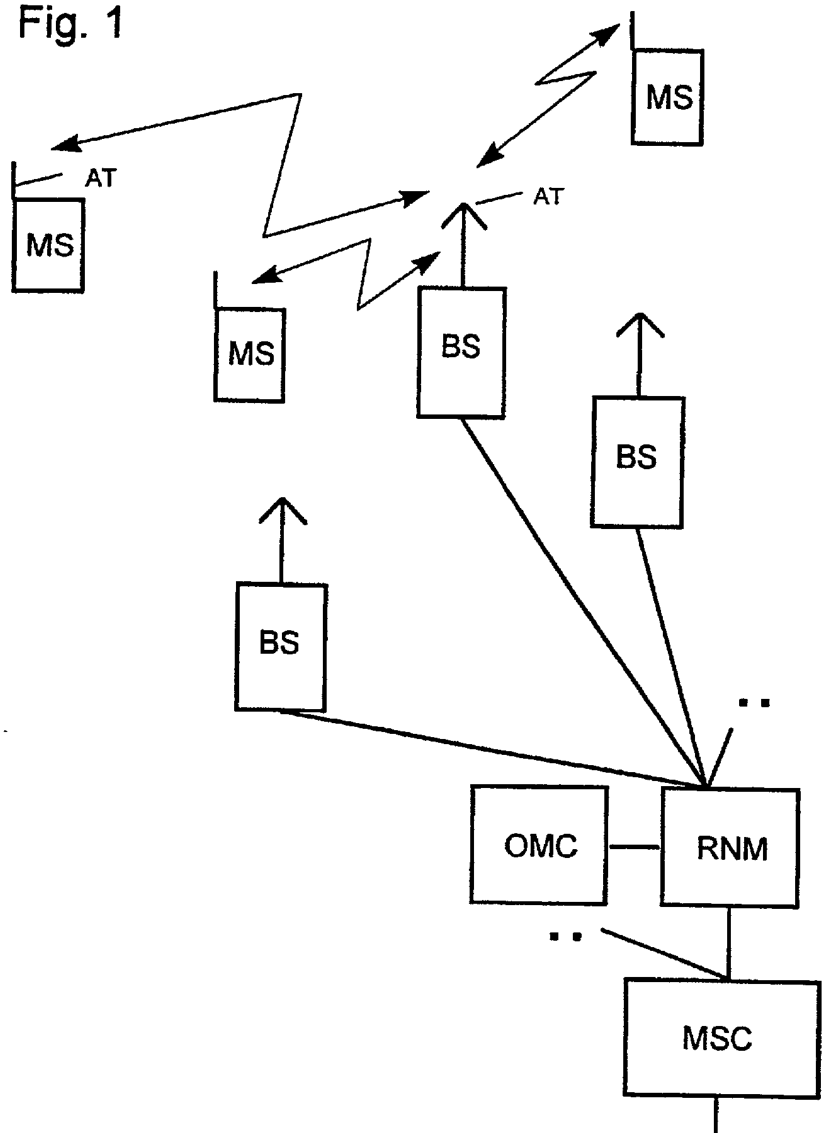
According to the invention, a maximum spread factor which can be predetermined is referred to in the event of a number of signals with different spread factors. At the receiving end, a number of virtual spread codes, which are each related only to individual symbols or symbol groups in the signal, are formed for a signal with a spread factor which is less than the maximum spread factor. These virtual spread codes are the basis for further evaluation of this signal, since the detection of this signal is carried out using the virtual spread codes. The detection results of the detection process with the virtual spread codes are then arranged in a row to form the receiving-end data stream of the signal.

Figure 5

09/831617



Fig. 1




(Prior Art)

Fig. 2

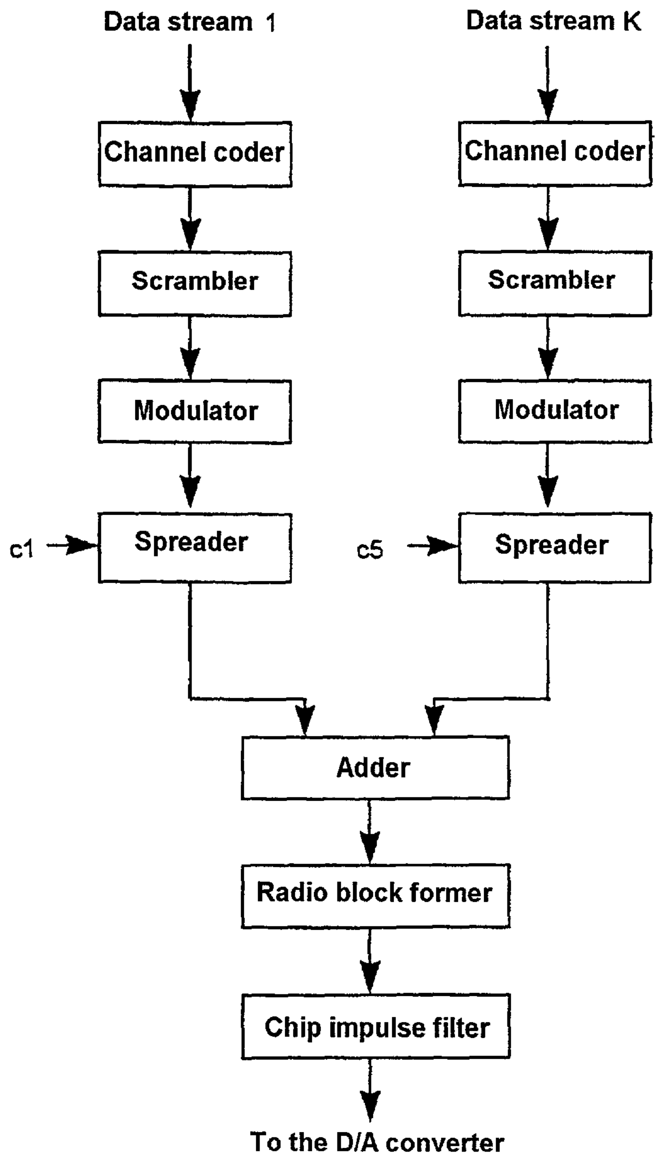

Data stream 1
Data stream K
Channel coder
Channel coder
Scrambler
Scrambler
Modulator
Modulator
c1
Spreader
c5
Spreader
Adder
Radio block former
Chip impulse filter
To the D/A converter

Fig. 3

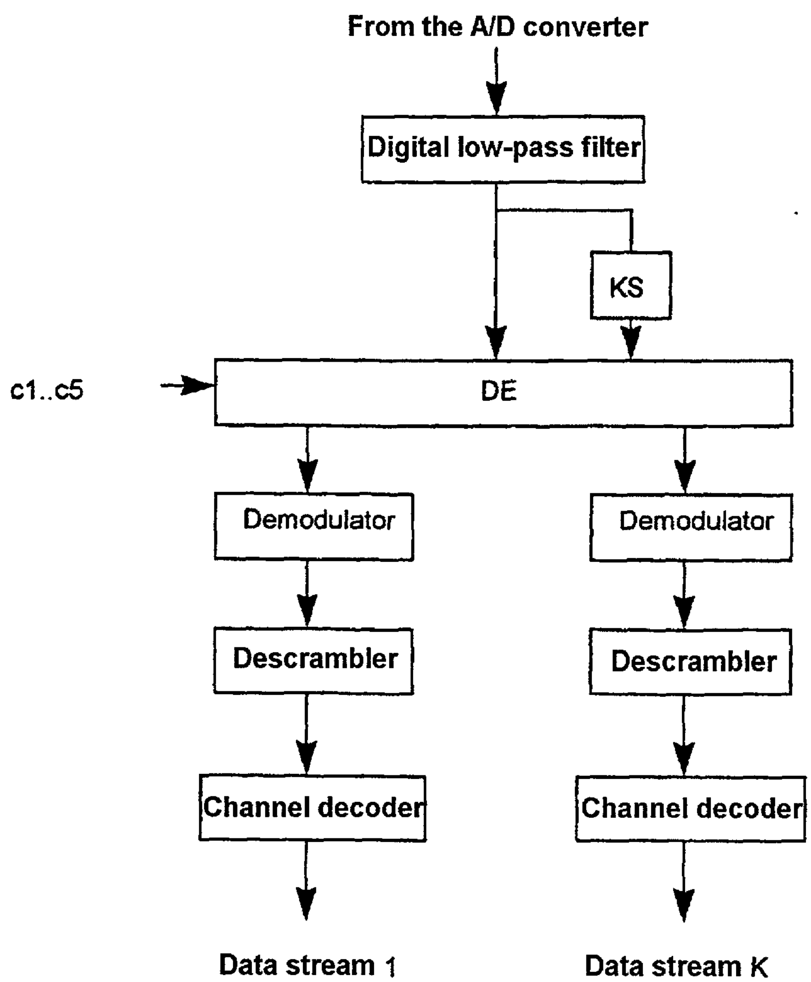

From the A/D converter
Digital low-pass filter
KS
c1..c5
DE
Demodulator
Demodulator
Descrambler
Descrambler
Channel decoder
Channel decoder
Data stream 1
Data stream K

Fig. 4

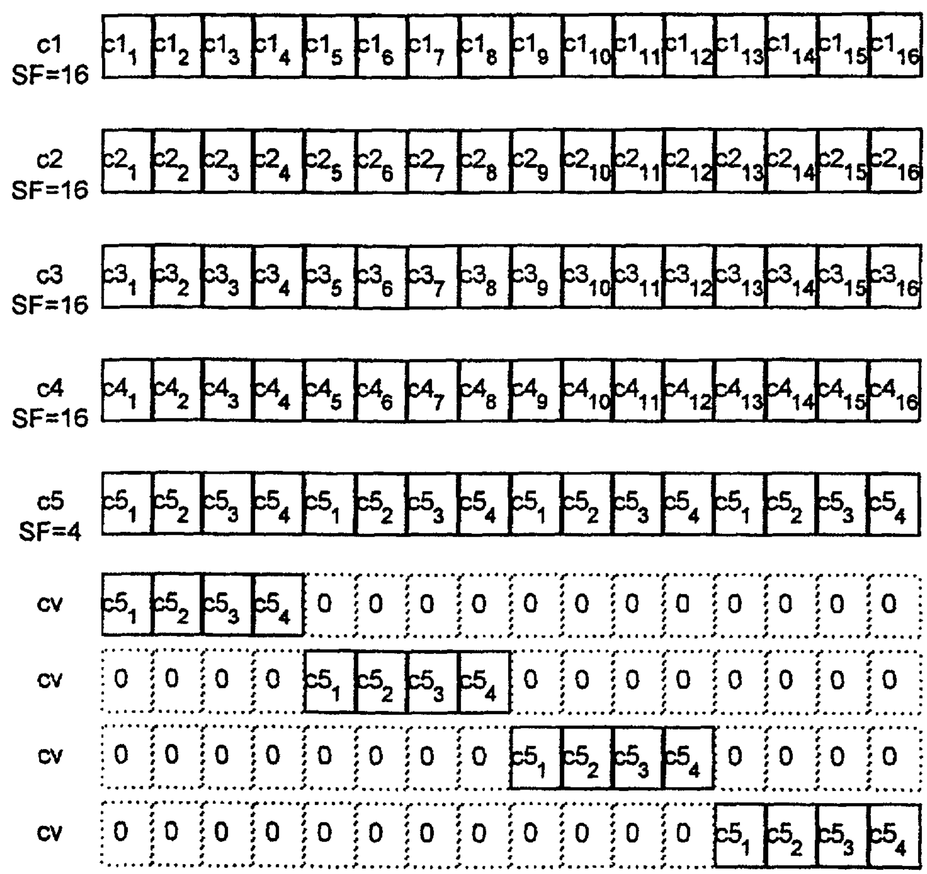
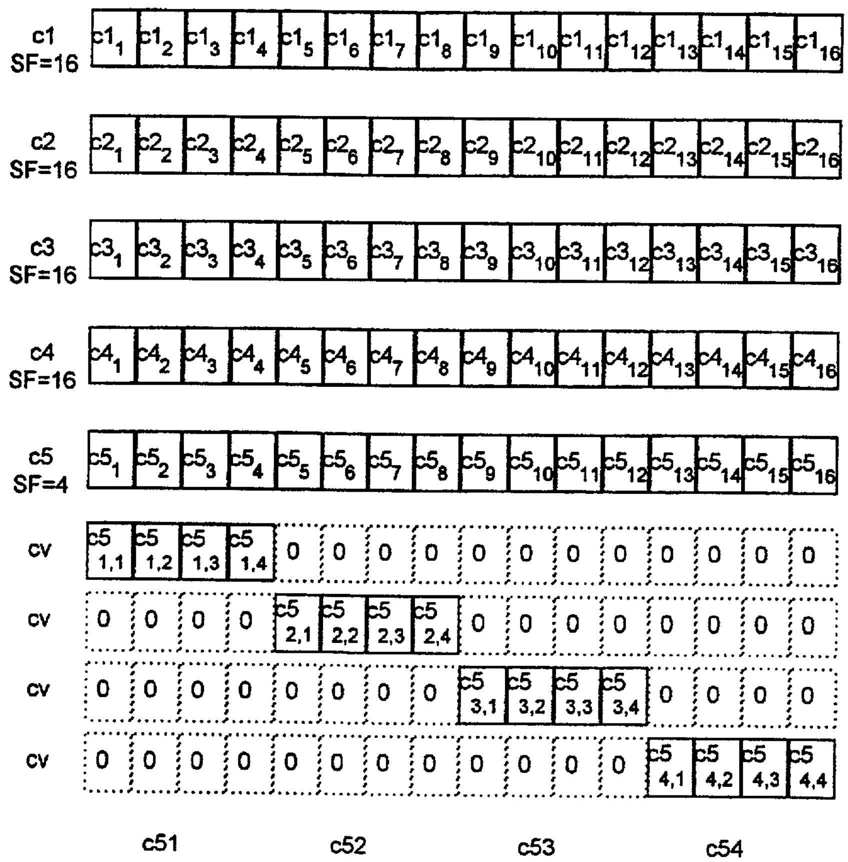

c1 SF=16
c1_1 c1_2 c1_3 c1_4 c1_5 c1_6 c1_7 c1_8 c1_9 c1_10 c1_11 c1_12 c1_13 c1_14 c1_15 c1_16
c2 SF=16
c2_1 c2_2 c2_3 c2_4 c2_5 c2_6 c2_7 c2_8 c2_9 c2_10 c2_11 c2_12 c2_13 c2_14 c2_15 c2_16
c3 SF=16
c3_1 c3_2 c3_3 c3_4 c3_5 c3_6 c3_7 c3_8 c3_9 c3_10 c3_11 c3_12 c3_13 c3_14 c3_15 c3_16
c4 SF=16
c4_1 c4_2 c4_3 c4_4 c4_5 c4_6 c4_7 c4_8 c4_9 c4_10 c4_11 c4_12 c4_13 c4_14 c4_15 c4_16
c5 SF=4
c5_1 c5_2 c5_3 c5_4 c5_1 c5_2 c5_3 c5_4 c5_1 c5_2 c5_3 c5_4 c5_1 c5_2 c5_3 c5_4
cv
c5_1 c5_2 c5_3 c5_4 0 0 0 0 0 0 0 0 0 0 0 0
cv
0 0 0 0 c5_1 c5_2 c5_3 c5_4 0 0 0 0 0 0 0 0
cv
0 0 0 0 0 0 0 0 c5_1 c5_2 c5_3 c5_4 0 0 0 0
cv
0 0 0 0 0 0 0 0 0 0 0 0 c5_1 c5_2 c5_3 c5_4

Fig. 5



# COMBINED DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled METHOD FOR TRANSMITTING DATA IN A RADIOCOMMUNICATION SYSTEM WITH CDMA SUBSCRIBER SEPARATION AND VARIABLE SPREAD FACTORS, the specification of which:

[X] was filed on May 10, 2001 as Application Serial No. 09/831,617.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information I know to be material to patentability in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

| Country | Application No. | Filing Date | Priority Claimed |
|---|---|---|---|
| Germany | DE 19852571.0 | November 13, 1998 | [X] Yes [] No |
| PCT | PCT/DE99/03614 | May 25, 2000 | [X] Yes [] No |

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patents issued thereon.

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Client's Ref. No.: 1998P08170WOUS

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